

System for information storage and/or reproduction and cassette for information storage and/or reproduction.

The invention relates to a system for the storage and/or reproduction of information, comprising a tape and a head for cooperation with the tape, which tape forms a spool on a first circularly cylindrical reel hub and is attached to a second circularly cylindrical reel hub, thus enabling the tape to be wound from the first onto the second reel hub, a part of said tape being positioned by a guide surface situated opposite the head, which guide surface has a tangent line which extends parallel to a connecting line interconnecting the centres of the reel hubs and which is situated at a distance h from the connecting line.

The invention also relates to a cassette for the storage and/or reproduction of information, comprising a tape in a housing having a window which provides access to a main surface of the tape, which tape forms a spool on a first circularly cylindrical reel hub and is attached to a second circularly cylindrical reel hub, a part of said tape being positioned by a guide surface situated opposite the window, which guide surface has a tangent line which extends parallel to a connecting line interconnecting the centres of the reel hubs and which is situated at a distance h from the connecting line.

Such a system and such a cassette are known from EP-B-0,206,392. The known system includes a cassette comprising two reel hubs and a rotatable tape guide. The tape is wound onto the reel hubs and between the reel hubs it is guided by the tape guide. The tape guide is located near a window in the cassette and supports the tape at the location of the window at the tape edge which is remote from the window. The window makes the tape accessible for an optical head of an apparatus adapted to read or write on the tape. A disadvantage of the known system and the known cassette is that out-of-roundness of the tape guide leads to a varying position of the tape at the location of the window relative to the optical head. Moreover, dirt and dust particles tend to settle on the surface of the rotatable tape guide and thereby affect the position of the tape at the location of the window.

It is an object of the invention to improve a system and a cassette of the type defined in the first and the second paragraph in such a manner that high-speed transport

of the tape is possible and at the same time the tape remains positioned correctly in order to be read by an optical head. To this end the system in accordance with the invention is characterised in that a cross-section of the guide surface taken perpendicularly to the axes of the reel hubs is substantially a segment of circle, which segment of circle has a radius R_4

5 which complies with the relationship:

$$0.5 R_3 \leq R_4 \leq R_3$$

in which R_3 is defined by the equation:

$$R_3 = \frac{\left[\frac{d}{2}\right]^2 + h^2 - R_2^2}{2(h - R_1)}$$

where

- 10 R_1 is the radius of the smaller reel hub,
 R_2 is the maximum radius of a spool, with the tape wholly wound on the reel hub having the larger radius, and
 d is the distance between the centres of the reel hubs.

An advantage is that a stable positioning of the tape is achieved in that the guide surface is stationary. Moreover, the tape slides over the guide surface, so that dirt and dust are readily carried off by the tape. This sliding of the tape over the guide surface is attended with friction. This friction is a factor which limits the tape transport speed. By dimensioning the guide surface in accordance with the invention an air cushion is already produced between the tape and the guide surface at a comparatively low transport speed. This air cushion provides a substantial reduction of the friction between the tape and the guide surface, so that high tape transport speeds are possible whilst the tape remains positioned correctly by the guide surface. Reading so-called address information from the tape is possible even at high transport speeds, thereby enabling a given piece of information on the tape to be retrieved rapidly. A measure of information retrieval is the so-called access time. This access time is the average time required to reach an arbitrary piece of information. The proposed steps enable the access time for a tape length of 100 metres to be reduced to a few seconds. This extends the range of application of a tape system. Moreover, in the case of existing uses, such as the recording and reproduction of audio or video information, the functionality can be improved significantly in that there is substantially direct access to any piece of information on the tape.

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An embodiment of the system in accordance with the invention is characterised in that the radius R_4 complies with the relationship:

$$R_4 = R_3.$$

This step provides a maximisation of the radius of the guide surface for the characteristic dimensions of the system. Since the thickness of the air cushion between the tape and the guide surface is directly proportional to the radius of the guide surface a maximal radius of the guide surface also provides a maximal thickness of the air cushion. A maximal thickness of the air cushion means that the friction between the tape and the guide surface is minimised.

An embodiment of the system in accordance with the invention is characterised in that

$$h = R_2.$$

This step minimises the angle of contact of the tape over the guide surface whilst under all circumstances the tape remains in contact with the guide surface at the location where the head cooperates with the tape. The friction between the guide surface and the tape is proportional to the force with which the tape is pressed onto the surface, which is referred to as the normal force. The normal force is directly proportional to the tension in the tape and the angle of contact. If now the angle of contact is minimised the normal force and hence the friction will also be minimised.

An embodiment of the system in accordance with the invention is characterised in that

$$R_1 \geq 0,5 R_2.$$

In this embodiment the radius of the smaller reel hub is selected to be greater than half the radius of the spool with the maximum diameter. This is uncommon in tape systems because this limits the length of tape that can be wound onto a reel hub. However, the proposed step enables the radius of the guide surface to be further increased so that the friction between the guide surface and the tape is further reduced. Since the storage capacity of a tape is high in comparison with, for example, a disc, this step improves the balance between storage capacity and access time.

The invention will now be described in more detail, by way of example, with reference to the drawing, in which

Figure 1 is a sectional view of an embodiment of the system in accordance with the invention,

Figure 2 diagrammatically shows the tape path in an embodiment of the system in accordance with the invention.

It is to be noted that the embodiments are shown diagrammatically and the
5 Figures are shown to an arbitrary scale, which is not always the same.

Figure 1 is a sectional view showing an embodiment of the system in accordance with the invention, which system includes a tape, in the present case an optically readable tape 13, accommodated in a housing 11 of a cassette 10, and a head for cooperation with the tape 13, in the present case an optical head 21 mounted in an apparatus 20. The tape
10 13 forms a spool 16 on a first circularly cylindrical reel hub 18. The tape 13 extends from this spool 16 to a second circularly cylindrical reel hub 19, to which the tape 13 is attached. A part of the tape is positioned by means of a guide surface 32 disposed opposite the head 21. In the present embodiment the guide surface 32 and the reel hubs 18 and 19 form part of the cassette 10. The head 21 of the apparatus 20 has access to a main surface of the tape 13
15 via a window 15 in the housing 11 of the cassette 10. Thus, the guide surface 32 is situated opposite the window 15. Moreover, the guide surface 32 is located in such a way relative to the reel hubs 18 and 19 that the guide surface 32 has a tangent line parallel to a connecting line 42 interconnecting the centres of the reel hubs 18 and 19 and situated at a distance h from the connecting line 42. The guide surface 32 has such a shape that a cross-section of
20 the guide surface taken perpendicularly to the axes of the reel hubs 18 and 19 is substantially a segment of circle. This segment of circle has a radius R_4 .

When the tape 13 is transported in that the reel hub 19 is driven the tape slides over the guide surface 32. In order to effect the transport of the tape 13 the tape has a given tension. Since the tape 13 runs over the guide surface 32 with an angle of contact α
25 this tape tension is converted into a force normal to the guide surface 32. This produces a frictional force between the tape 13 and the guide surface 32, which force is directly proportional to the normal force. When the tape 13 is wound onto the reel hub 19 at high speed a considerable tensile stress in the tape is required in order to ensure a satisfactory winding. This is necessary because at high speeds air is pumped between the tape 13 and the
30 spool, which may give rise to so-called air inclusions. These air inclusions result in slack winding. In the case of slack winding the reel hub 19 may rotate while the tape is stationary. This effect results from the fact that the pressure in the air inclusions decreases through leakage via the spool sides and the air inclusions are removed as the tape 13 in fact tightens around the reel hub 19. This effect is highly undesirable in a system in which the position of

the tape 13 relative to the head is exclusively determined by the drive of the reel hubs 18 and 19.

The sliding cooperation of the tape 13 with the guide surface 32 produces friction between the tape and the guide surface. The friction gives rise to heating of the guide surface 32 and the tape 13 and additional power is needed to drive the tape 13, which limits the transport speed. This transport speed is an important parameter for tape systems because the tape 13 often has a length of approximately 100 metres and, as a consequence, a rapid transport is needed to gain access to a given piece of information on the tape 13 within a short time. This time, often referred to as access time, consequently decreases as the friction is reduced. The friction is reduced significantly by the build-up of an air cushion between the guide surface 32 and the tape 13. The friction decreases as the thickness of the air cushion increases and the thickness of the air cushion is directly proportional to the radius R_4 of the guide surface 32. Given the characteristic dimensions of the system the access time can therefore be reduced by optimising R_4 . How the optimum value for the radius R_4 can be derived will now be explained with reference to Figure 2.

Figure 2 shows diagrammatically an embodiment of the system in accordance with the invention in which the guide surface 32 has an optimum radius R_3 for the characteristic dimensions of the system. A tape span 13a extends from the empty reel hub 18 to the guide surface 32. In order to ensure uniform contact between the tape 13 and the guide surface 32 the direction of the tape span 13a should correspond to the direction of the tangent line to the guide surface 32 through the point where the tape span 13a is tangent to the guide surface 32, which point is referenced E in the present case. The diagrammatic representation in Figure 2 clearly shows that given this requirement the radius R_3 is maximal if the guide surface 32 extends up to the spool 16 (tape 13 wholly wound onto the reel hub 18). Depending on the positions of the guide surface 32 and the reel hubs 18 and 19 relative to one another the optimum radius R_3 is derived as follows:

$$\left. \begin{array}{l} R_3 = AE = AD + DE \\ DE = FG = R_1 \end{array} \right\} R_3 = AD + R_1 \Leftrightarrow AD^2 = (R_3 - R_1)^2 \quad (1)$$

$$AD^2 = AG^2 - DG^2 \quad (2)$$

$$AG^2 = BG^2 + AB^2 \quad |$$

$$AB = |h - R_3| \Leftrightarrow AB^2 = (R_3 - h)^2 \quad \left\{ \begin{array}{l} AG^2 = \left[\frac{d}{2} \right]^2 + (h - R_3)^2 \end{array} \right. \quad (3)$$

$$BG = \frac{d}{2}$$

$$DG^2 = EG^2 - DE^2$$

$$EG = R_2$$

$$DE = FG = R_1$$

J

J

$$DG^2 = R_2^2 - R_1^2$$

(4)

Inserting (1), (3) and (4) in (2) yields:

$$(R_3 - R_1)^2 = \left(\frac{d}{2}\right)^2 + (h - R_3)^2 - (R_2^2 - R_1^2)$$

$$R_3^2 - 2R_1R_3 + R_1^2 = \left(\frac{d}{2}\right)^2 + R_3^2 - 2hR_3 + h^2 - R_2^2 + R_1^2$$

$$-2R_1R_3 = \left(\frac{d}{2}\right)^2 + -2hR_3 + h^2 - R_2^2$$

$$2(h - R_1)R_3 = \left(\frac{d}{2}\right)^2 + h^2 - R_2^2$$

$$R_3 = \frac{\left(\frac{d}{2}\right)^2 + h^2 - R_2^2}{2(h - R_1)}$$

in which R_1 is the radius of the reel hub 18, R_2 is the maximum radius of the spool 16 with the tape 13 wholly wound onto the reel hub 18, h is the distance between the tangent line 41 to the guide surface 32 and the connecting line 42, and d is the distance between the centres of the reel hubs 18 and 19. Consequently, this R_3 is the optimum value for the radius R_4 of the guide surface 32. However, it has been found that satisfactory results can be obtained already if the radius R_4 of the guide surface 32 is between $0.5 R_3$ and R_3 .

The head 21 of the apparatus 20 cooperates with the tape 13 at a location C in Figure 2. In order to ensure that the tape 13 is always in contact with the guide surface 32 at the location of this point C the distance h between this point C and the connecting line 42 should at least equal R_2 . The angle of contact, marked α in Figure 1, increases as this distance h is enlarged. Increasing of the angle of contact α also causes the total normal force on the guide surface 32 and hence the friction between the tape 13 and the guide surface 32 to increase. In the optimum configuration h is therefore equal to R_2 .

From the foregoing it also follows that R_3 increases as R_1 approximates to the distance h . As R_1 increases the length of tape 13 which can be accommodated in the cassette 10 and hence the storage capacity of the cassette 10 will decrease. In tape systems R_1 is therefore usually selected in such a way that $R_1 < \frac{1}{2}R_2$. However, as R_1 increases the optimum radius R_3 also increases which has a favourable effect on the friction between the tape 13 and the guide surface 32. Thus, the access time can be reduced by increasing R_1 . A satisfactory balance between storage capacity and access time is achieved by selecting the radius R_1 of the smaller reel hub in such a manner that $R_1 > 0.5 R_2$.

It is to be noted that the invention is not limited to the embodiments shown herein. Various other embodiments are possible without departing from the scope of the present invention. For example, the system in accordance with the invention need not be based on a cassette 10 but can be based on separate reel hubs 18 and 19, the guide surface 32 forming part of the apparatus 20. Moreover, the invention can also be applied to a system with, for example, a magnetic head.

CLAIMS:

1. A system for the storage and/or reproduction of information, comprising a tape (13) and a head (21) for cooperation with the tape, which tape forms a spool (16) on a first circularly cylindrical reel hub (18) and is attached to a second circularly cylindrical reel hub (19), thus enabling the tape to be wound from the first onto the second reel hub, a part of said tape being positioned by a guide surface (32) situated opposite the head, which guide surface (32) has a tangent line (41) which extends parallel to a connecting line (42) interconnecting the centres of the reel hubs (18, 19) and which is situated at a distance h from the connecting line (42), characterised in that a cross-section of the guide surface (32) taken perpendicularly to the axes of the reel hubs is substantially a segment of circle, which segment of circle has a radius R_4 which complies with the relationship:

$$0.5 R_3 \leq R_4 \leq R_3$$

in which R_3 is defined by the equation:

$$R_3 = \frac{\left[\frac{d}{2}\right]^2 + h^2 - R_2^2}{2(h - R_1)}$$

15 where

- R_1 is the radius of the smaller reel hub,
 R_2 is the maximum radius of a spool (16), with the tape (13) wholly wound on the reel hub having the larger radius, and
 d is the distance between the centres of the reel hubs (18, 19).

- 20 2. A system as claimed in Claim 1, characterised in that the radius R_4 complies with the relationship:

$$R_4 = R_3.$$

3. A system as claimed in Claim 1 or 2, characterised in that
 $h = R_2.$

- 25 4. A system as claimed in Claim 1, 2 or 3, characterised in that



$$R_1 \geq 0,5 R_2.$$

5. A cassette (10) for the storage and/or reproduction of information,

- comprising a tape (13) in a housing (11) having a window (15) which provides access to a main surface of the tape,

5 - which tape forms a spool (16) on a first circularly cylindrical reel hub (18) and is attached to a second circularly cylindrical reel hub (19),

- a part of said tape being positioned by a guide surface (32) situated opposite the window,

10 - which guide surface (32) has a tangent line (41) which extends parallel to a connecting line (42) interconnecting the centres of the reel hubs (18, 19) and which is situated at a distance h from the connecting line (42),

characterised in that

- a cross-section of the guide surface (32) taken perpendicularly to the axes of the reel hubs is substantially a segment of circle,

15 - which segment of circle has a radius R_4 which complies with the relationship:

$$0.5 R_3 \leq R_4 \leq R_3$$

in which R_3 is defined by the equation:

$$R_3 = \frac{\left[\frac{d}{2}\right]^2 + h^2 - R_2^2}{2(h - R_1)}$$

where

20 R_1 is the radius of the smaller reel hub,

R_2 is the maximum radius of a spool (16), with the tape wholly wound on the reel hub (18) having the larger radius, and

d is the distance between the centres of the reel hubs (18, 19).

6. A cassette as claimed in Claim 5, characterised in that

25 $R_4 = R_3.$

7. A cassette as claimed in Claim 5 or 6, characterised in that

$$h = R_2.$$

8.

A cassette as claimed in Claim 5, 6 or 7, characterised in that

$$R_1 \geq 0,5 R_2.$$

